

## OPPORTUNITY

How much energy is used for heating, ventilation and air conditioning (HVAC) in U.S. office buildings?

**34%**  
**OF ENERGY**  
GOES TO HVAC<sup>1</sup>

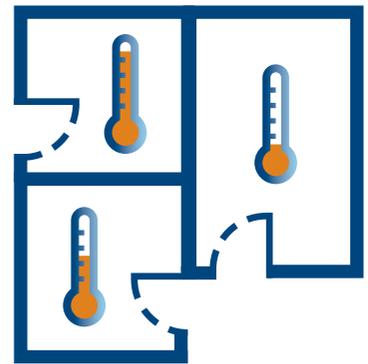
**3%**  
**OF U.S. OFFICE BUILDINGS RELY ON VRF<sup>2</sup>**  
PRIMARY HVAC SYSTEM IN EUROPE,  
JAPAN AND CHINA<sup>3</sup>

## TECHNOLOGY

How does VRF work?

**PROVIDES INDEPENDENT TEMPERATURE CONTROL**  
TO ROOMS THROUGHOUT BUILDING

**USES REFRIGERANT**  
AS COOLING/HEATING MEDIUM;  
SUBSTITUTING THIN PIPES FOR  
DUCTWORK



## M&V

Where did Measurement and Verification occur?

**PACIFIC NORTHWEST NATIONAL LABORATORY** drew from a wide variety of sources to evaluate the performance of VRF for GSA buildings

## RESULTS

How did VRF perform in M&V?

**34%**  
**ENERGY SAVINGS**  
PROJECTED  
RELATIVE TO  
CODE-COMPLIANT  
HVAC<sup>4</sup>

**THIN PROFILE**  
ADVANTAGEOUS IN  
HISTORIC BUILDINGS  
WITH LIMITED ROOM  
FOR DUCTWORK<sup>5</sup>

**COST-EFFECTIVE**  
WHEN THE PREMIUM  
IS < \$4/SQ.FT.  
COMPARED TO CODE-  
COMPLIANT HVAC<sup>6</sup>

## Projected Payback for VRF vs VAV

Reasonable paybacks achievable (shown in white)

### VRF vs VAV with Gas Reheat or Cav

34% Projected Energy Cost Savings

Added Cost \$/ft <sup>2</sup>	Energy Cost Savings, \$/ft <sup>2</sup>							
	\$10	\$14	*\$18	\$22	\$26	\$30	\$34	\$38
\$1	10	7	6	5	4	3	3	3
\$2	20	14	11	9	8	7	6	5
\$3	30	21	17	14	12	10	9	8
**\$4	40	29	22	18	15	13	12	11
\$5	50	36	28	23	19	17	15	13
\$6	60	43	33	27	23	20	18	16

### VRF vs VAV with Electric Reheat

45% Projected Energy Cost Savings

Added Cost \$/ft <sup>2</sup>	Energy Cost Savings, \$/ft <sup>2</sup>							
	\$13	\$19	*\$24	\$29	\$34	\$40	\$45	\$50
\$1	8	5	4	3	3	3	2	2
\$2	15	11	8	7	6	5	4	4
\$3	23	16	13	10	9	8	7	6
**\$4	30	22	17	14	12	10	9	8
\$5	38	27	21	17	15	13	11	10
\$6	45	32	25	21	17	15	13	12

\* Average GSA Portfolio Energy Cost Savings (based on GSA average usage of 60.7 kBtu/ft<sup>2</sup>, GSA average cost of \$0.89/therm, and EIA average cost of \$0.10/kWh)

\*\* Average Added Cost

## DEPLOYMENT

Where does M&V recommend deploying VRF?

## PILOT PROJECTS

Research on field performance is limited

<sup>1</sup>Variable Refrigerant Flow Systems. Brian Thornton, Anne Wagner (PNNL), December 2012, p.4 <sup>2</sup>Ibid, p.11 <sup>3</sup>Ibid, p.4 <sup>4</sup>Ibid, p.13 <sup>5</sup>Ibid, p.24 <sup>6</sup>Ibid, p.46